PAWS Systems
Portable Acoustic Wave Sensor Systems

A variety of portable environmental monitoring systems have been designed, built, and field tested using surface acoustic wave (SAW) devices to provide rapid, reversible, sensitive, and quantitative detection of individual volatile organic compounds (VOCs). The latest and smallest system (shown in Figure 1) is housed in a 5.5"x3.3"x1.5" plastic case (approximately 27 cubic inches) and includes batteries for portable or field operation. Although this system consists of a single SAW sensor, a larger portable instrument based on a SAW sensor array using selective coatings on separate sensors to provide simultaneous chemical identification and quantitation of one or more VOCs has been fabricated.

Applications

PAWS sensing systems have been shown to provide rapid, reversible, sensitive, and quantitative detection of individual VOCs. Their stable calibration and ease of use make them ideal for selected applications. Demonstrated and potential applications include:

- on-line monitoring of industrial and environmental remediation processes
- in-situ environmental monitoring (long term post closure monitoring)
- industrial hygiene monitoring
- analysis of VOC contamination in water
- detection of explosives and chemical weapons (counterterrorism, nonproliferation)

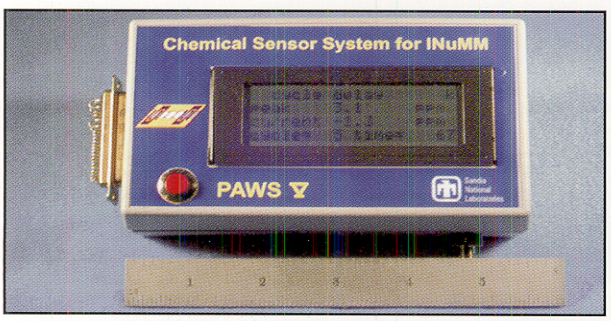

Figure 1: Picture of battery operated portable acoustic wave sensor system for monitoring trace concentrations of VOCs.

Technical Approach

As shown in Figure 2, SAW devices consist of a piezoelectric substrate, typically quartz, and two interdigitated transducers formed by photolithographic patterning of a thin metal layer. Application of an alternating voltage to the input transducer generates an alternating strain field that launches a surface acoustic wave that travels along the substrate surface before being converted back into an electrical signal by the output transducer. The velocity and attenuation of the propagating wave are very sensitive to properties, such as mass and viscoelasticity, of thin films formed on the device surface. For example, increases in surface mass loading cause decreases in wave velocity that can be used to detect picogram (10^{-12} g) mass changes. By coating the acoustic path with a material that sorbs a chemical analyte of interest, this sensitivity can also be used to develop chemical sensors. Although the SAW device is the heart of the portable sensor, a variety of supporting circuitry and sample handling devices have been incorporated into the hand-held device.

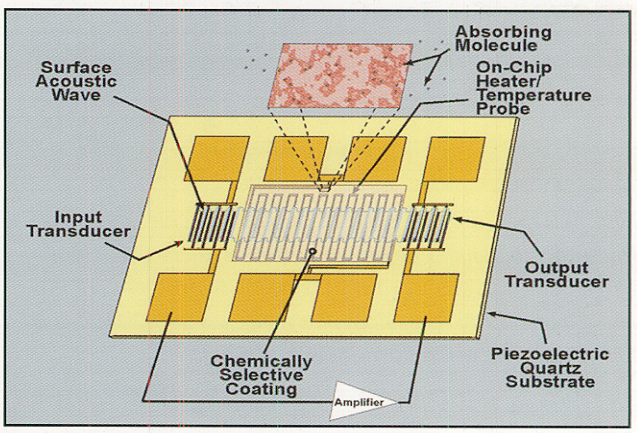

Figure 2: Schematic of a surface acoustic wave (SAW) sensor.

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The system includes the following components:

1. One polyisobutylene-coated quartz SAW for detecting organic solvents,
2. SAW drive circuit (U.S. Patent #5,763,283) that reduces power needs by more than 80% over previous designs,
3. Data acquisition and control (DAC) board optimized for lower power operation and a 4 line display,
4. Small tubular adsorbent preconcentrator with a resistive wire heater,
5. Nafion™ membrane for humidity control,
6. Small rotary vane pump,
7. Three latching relays to activate the pump at both high and low flow rates and to turn on the preconcentrator heater and the SAW drive electronics, and
8. Batteries.

The total power use for the prototype is about 11 mA-hr @ 3.6 V for one analysis cycle.

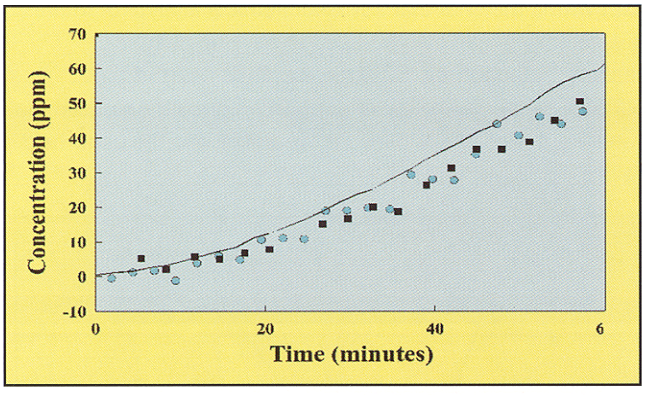

Figure 3: In-situ monitoring of carbon tetrachloride at the Hanford site using a down hole PAWS system (■). Good agreement was observed with baseline instruments (line) and a second PAWS system analyzing gas samples pushed to the surface by the down hole probe (o).

In addition to the hand-held model, we have fabricated sensors that have been used in down-hole monitors for VOC detection as well as models modified for detection of organics in water using a purge and trap technique. These instruments have been used in field trials at various DOE sites including Savannah River and Hanford. These sensing systems have performed well on a variety of chlorinated solvents dispersed in air or water. Figure 3 shows the results of testing at one of the field demonstration tests.

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